STABRO LABORA
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INSTRUCTION BOOK
MODEL 74C - S1
CAPACITANCE BRIDGE

SERIAL # 449

Boonton ELECTRONICS Corporation

MORRIS PLAINS, NEW JERSEY

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INSTRUCTION BOOK
MODEL 74C - S1
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The Model 74C - S1 is basically the same as a standard Model 74C Capacitance Bridge, but operates at 1 KC and uses a different type of oscillator and indicator amplifier.

The main differences are:

1. Operating frequency of 1 KC.
2. DIRECT capacitance measurements only.
3. The level of the TEST signal is not adjustable as in the Model 74C.

Supplementary sheets with a "Normal Operating Voltage" table and "Oscillator-Indicator Amplifier Adjustments" have been included as well as added schematic and parts list information. These have been inserted at the back of this book ahead of the main schematic.

Boonton *ELECTRONICS* Corporation

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74C CAPACITANCE BRIDGE

INSTRUCTION BOOK

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SECTION I

SPECIFICATIONS

Capacitance Range	.0002 μμf to 11,000 μμf
Conductance Range	.001 micromho to 1,000 micromhos
Resistance Range	1,000 Ω to 1,000 megohms
*Direct Capacitance Accuracy	±(0.25%) + Range Factor
*Grounded Capacitance Accuracy	±(0.25% + 0.5 μμf)
*Conductance Accuracy	± 10% + Range Factor
*Resistance Accuracy	± 10% + Range Factor
Frequency	100 kilocycles
Test Signal Level	
HI-LO switch on LO	approx. 20 mv to .8v
HI-LO switch on HI	approx. .6v to 3v.
Power Requirements	105-125 volts, 50-60 cy. 30 watts
Weight	22 pounds
Size	Width 14", Height 11" Depth 8 1/2"
Tubes	1-6X4, 1-0A2, 2-6AU6, 1-6C4

*See Section IV, page 4

SECTION II

GENERAL DESCRIPTION

The Model 74C Three-Terminal Capacitance Bridge was designed to provide the industry with a compact self-contained precision instrument for measuring capacitance and conductance. Measurements may be made by either the direct or grounded method.

When the direct method is used, stray or test cable capacitances to ground do not affect the measurement, and small values of capacitance may be measured easily and accurately.

The wide range of capacitance and conductance measurements possible - .0002 μμf to 11,000 μμf and .001 to 1,000 micromhos is obtained without auxiliary equipment. Below 1000 μμf, the capacitance and conductance of the test are both read directly from their respective dials. See note at foot of Section IV "Range and Accuracy".

SECTION III

DIRECT CAPACITANCE VS. GROUNDED CAPACITANCE

Direct capacitance is the capacitance existing between two conducting elements, excluding all stray capacitance that may exist by way of a third or fourth, etc. conducting element.

Typical examples of direct capacitance measurement applications are the following:

1. Capacitance between control grid and plate of vacuum tubes, excluding capacitance to cathode, screen grid, or suppressor.
2. Capacitance between any two conductors in a cable, excluding capacitance to all other conductors or shield.
3. Capacitance between any two conductors of a printed circuit, excluding capacitance to all other conductors.
4. Capacitance between any two windings of a transformer, excluding capacitance to all other windings or shields.

Grounded capacitance is the capacitance existing between two conducting elements when one element is grounded, and includes all stray capacitance from the high element to ground, either directly or by way of adjacent elements. For this reason, a grounded capacitance reading will always be greater than a direct one, and will depend somewhat on proximity of chassis and adjacent components, and on measuring technique.

RANGE AND ACCURACY DETAILS

CAPACITANCE RANGES:

Multiplier	Cap. Range	Accuracy *** Direct*	Grounded*
1.0	100 to 11,000 μμf	±(0.25% + 0.2 μμf)	±(0.25% + 0.5 μμf)
.1	10 to 100 μμf	±(0.25% + 0.02 μμf)	±(0.25% + 0.5 μμf)
.01	1 to 10 μμf	±(0.25% + 0.005 μμf)	±(0.25% + 0.5 μμf)
.001	0.05 to 1 μμf	±(0.25% + 0.001 μμf)	±(0.25% + 0.5 μμf)
.001	0 to 0.05 μμf	+(2 % + 0.0002 μμf)	- - - - - - - -- -

CONDUCTANCE RANGES:

Divider	Cond. Range	Accuracy**
1	100 to 1000 μmhos	±(10% + 10 μmhos)
10	10 to 100 μmhos	±(10% + 1 μmho)
100	1 to 10 μmhos	±(10% + 0.1 μmho)
1,000	0.1 to 1 μmho	±(10% + 0.01 μmho)
10,000	0 to 0.1 μmho	±(10% + 0.001 μmho)

RESISTANCE RANGES:

Multiplier	Resistance Range	Accuracy**
1	1K to 10K ohms	$\pm(10\% + \frac{R}{10^3}\ \%)$
10	10K to 100 K ohms	$\pm(10\% + \frac{R}{10^4}\ \%)$
100	100K to 1 megohm	$\pm(10\% + \frac{R}{10^5}\ \%)$
1K	1 megohm to 10 megohms	$\pm(10\% + \frac{R}{10^6}\ \%)$
10K	10 megohms up	$\pm(10\% + \frac{R}{10^7}\ \%)$

(Where R is resistance of the test in ohms)

NOTES:

* This accuracy depends largely upon measuring techniques employed. See Section VI of this manual.

** Specified CONDUCTANCE and RESISTANCE accuracies apply only below 1000 μμf and when the test is connected directly to the HI and LO TEST binding posts.

*** Minimizing Errors Due to Shift of Capacitance Zero with Temperature Changes

Normally the amount of capacitance shift during warm-up is not troublesome unless very close measurements are being made.

Warm-up time for stability is approximately 5 hours. Hence, when the greatest possible stability is required we recommend that the bridge be left "on" continuously, and that changes in room ambient temperature be kept to a minimum (the zero shift of a fully stabilized 74C is approximately -.0033 μμf per degree centigrade).

SECTION V

OPERATING PROCEDURE FOR DIRECT OR GROUNDED MEASUREMENTS AT THE "HI" AND "LO" "TEST" BINDING POSTS

5.1 SETUP AND ZERO BALANCING

1. Turn on power. Switch to direct or grounded method of measurement as desired (See Section III for definitions of each).
2. Set conductance range selector switch (marked DIVIDE G/ MULTIPLY R) to 1K.
3. Set the MULTIPLY CAPACITANCE and ADD CAPACITANCE switches to position indicated in Table I.

TABLE I

Capacitance to be Measured	MULTIPLY CAPACITANCE Control Setting	ADD CAPACITANCE Control Setting
1000 to 11,000 μμf	1	1K thru 10K
100 to 1,000 μμf	1	0
10 to 100 μμf	.1	0
1 to 10 μμf	.01	0
0 to 1 μμf	.001	0

4. Set the CONDUCTANCE dial to zero.
5. Set the CAPACITANCE dial to zero. (Both vernier and counter dials should read zero).

6. Adjust zero balance controls (located directly above the CAPACITANCE and CONDUCTANCE dials) until the NULL INDICATOR meter reads zero. FINE capacitance zero control should be set with pointer straight up before adjusting COARSE control. SENSITIVITY control should be set to approximately mid-position. Too high a sensitivity control setting will result in unnecessary difficulty in obtaining a null indication. Too low a setting will result in reduced resolution and measuring accuracy.
7. Connect the test capacitor to the HI and LO TEST posts. See Section VII MEASURING TECHNIQUES for suggested connection procedure.

5.2 MEASURING

1. Adjust CAPACITANCE and CONDUCTANCE dials until meter in-indicates best null. Reduce or increase the setting of the SENSITIVITY control as indicated if difficulty is had in obtaining a satisfactory null. For best accuracy the null should obtain between 100 and 1000 on both the CAPACITANCE and CONDUCTANCE dials. If it appears above or below these points, the next indicated MULTIPLY CAPACITANCE and/or DIVIDE G/MULTIPLY R range should be used.

NOTE:

Whenever the capacitance or conductance ranges are changed the capacitor to be measured must be disconnected and the bridge zero balanced as detailed in Section V 5.1 .

5.3 INTERPRETING READINGS

1. Capacitance

After balancing capacitance and conductance to a satisfactory degree of precision, the capacitance of the test is determined directly from the CAPACITANCE dial reading, multiplied by the decimal factor indicated on the MULTIPLY CAPACITANCE dial. Capacitance values above 1000 μμf are determined by adding the reading of the CAPACITANCE dial to the reading of the ADD CAPACITANCE control.

2. Conductance

For values below 1000 μμf*, the conductance of the test (at 100 KC) is determined by dividing the reading indicated on the G scale of the CONDUCTANCE dial by the factor indicated on the DIVIDE G/MULTIPLY R dial.

3. Resistance

For values below 1000 μμf*, the equivalent shunt resistance (at 100 KC) is determined by multiplying the reading indicated on the R scale by the factor shown on the DIVIDE G/MULTIPLY R dial.

* When measuring capacitance values above 1000 μμf, conductance and equivalent shunt resistance readings should not be used directly, since the readings actually represent the difference in conductance/shunt resistance between the test capacitor and the capacitor (s) of the ADD CAPACITANCE network that are in the circuit for the measurement.

4. The Q and Dissipation Factor (D) of the test capacitor at 100 KC may be computed from the following formulae:

$$Q = \frac{.628\ C}{G} \qquad D = \frac{1}{Q}$$

Where:
C is capacitance in $\mu\mu f$
G is conductance in micromhos

SECTION VI

REMOTE MEASUREMENTS (DIRECT only)

6.1 GENERAL

When certain limitations are kept in mind, remote measurements may be made as easily and, in general, more accurately than those at the binding posts.

The use of reasonable lengths (up to 6 feet or so) of RG-58/U coaxial cable produces a small zero offset that is readily eliminated when zero balancing.

For values of test capacitance above about 1000 μμf, the inductance of long coaxial cables results in an increase in capacitance and conductance readings that cannot be eliminated by zero balancing. This increase is approximately + .008%/1000 μμf of test capacitance/foot of extension of test cable (length of one cable).

See Table II below for selected examples.

TABLE II

Increase in Capacitance Reading due to Inductance Of Remote Coaxial Cables (RG-58/U only)

Capacitance Value Being Measured (μμf)	Increase in Capacitance Reading			
	For 1 Ft. Cables		For 6 Ft. Cables	
	%	μμf	%	μμf
1,000	.008	.08	.048	.48
5,000	.04	2	.24	12
10,000	.08	8	.48	48

6.2 SETUP AND ZERO BALANCING

1. Turn on power and switch to DIRECT.
2. Set the DIVIDE G/MULTIPLY R switch to 1K.
3. Set the MULTIPLY CAPACITANCE and ADD CAPACITANCE switches to positions indicated in Table I.
4. Set the CONDUCTANCE and CAPACITANCE dials to zero.
5. Connect the coaxial cables to the HI and LO REMOTE TEST jacks on the bridge, and the center conductor of the LO coaxial cable to the terminal of the test capacitor that has the larger capacitance to ground (if this is known), otherwise to either terminal of the test capacitor. Connect the braid of the coaxial cables together at the test end.
6. Adjust zero balance controls (located directly above the CAPACITANCE and CONDUCTANCE dials) until the NULL INDICATOR meter reads zero. FINE capacitance zero control should be set with pointer straight up before adjusting COARSE control. SENSITIVITY control should be set to approximately mid-position. Too high a SENSITIVITY control setting will result in unnecessary difficulty in obtaining a null indication. Too low a setting will result in reduced resolution and measuring accuracy.
7. Connect the center conductor of the HI coaxial cable to the other terminal of the test.

6.3 MEASURING AND INTERPRETING READINGS

Procedure is identical to that for tests at the HI and LO TEST binding posts. (See Section V, 5.2 and 5.3).

SECTION VII

MEASURING TECHNIQUES

7.1 GENERAL

Direct capacitance measurements can be made to a higher degree of accuracy than grounded measurements, particularly when the test capacitance is small (less than 100 μμf) and when long test leads are necessary. Use of the direct method also greatly reduces hand capacitance effects as well as the test capacitor position error.

When direct capacitance measurements are made at the end of coaxial cables, the cables may be bent, twisted or moved and subjected to wide temperature variations without affecting test accuracy.

Much of the accuracy of capacitance measurement depends on the technique of connecting the test capacitor to the bridge. For example, when measuring the grounded capacitance of a 10 μμf mica capacitor the variation due to connection technique may reach as much as 1 μμf.

7.2 DIRECT CAPACITANCE MEASUREMENTS

Whether measurements are being made at the TEST posts or at the end of remote cables connected to the REMOTE TEST coaxial jacks, the test capacitor should be connected with as short leads as possible.

In many cases it may be convenient to connect the test by inserting its wire leads directly into the center conductor of the HI and LO coaxial TEST jacks. This has the advantage that the outer shell of each jack shields the leads from each other for much of their length.

If extreme accuracy is required, it is usually best to use a test fixture to keep the capacitance between the leads of the test from influencing the measurement.

All other conductors in the immediate vicinity of the elements under test must be connected to ground.

7.3 GROUNDED CAPACITANCE MEASUREMENTS

Grounded capacitance measurements are inherently less accurate than direct capacitance measurements owing to unavoidable stray capacitance variations between the HI test lead and ground.

Although these variations may amount to 1 μμf or more, it is usually possible to reduce this uncertainty to less than 0.5 μμf by using the following procedure when preparing a test specimen:

1. Connect the ground side of the test to the LO binding post using a short length of wire.
2. Connect a short length of bare tinned copper wire to the HI binding post. Bend this wire so it approaches the test sample perpendicularly and is spaced away from all surrounding objects as much as possible. The free end should be spaced approximately 1/4 inch from the high terminal of the sample for bridge zero balance adjustments. The final measurement is made with this wire connected to the test specimen.

Contact fixtures may be used for production testing provided their residual capacitance does not exceed the range of the COARSE and FINE controls (approx. 10 μμf).

SECTION VIII

MAINTENANCE

8.1 GENERAL

The capacitance bridge has been carefully calibrated at the factory against three-terminal capacitance standards certified by the National Bureau of Standards. Unless comparable standards are used, re-calibration of this instrument by other than the manufacturer is inadvisable.

8.2 REMOVING FROM THE CABINET

Remove the two screws holding the chassis to the bottom of the cabinet and the four screws at the outer edges of the panel. Remove Binding Post Jack Assembly from top of cabinet. The instrument may now be eased out of the cabinet.

8.3 CHECKING TUBES

Tubes may be checked on any good tube checker, and replaced if found to be weak. No tube selection is necessary. Access to the 100 KC oscillator (6C4) tube may be had by removing the two screws holding the shield can (marked "6C4")located underneath the main chassis, and lifting off the can. Care should be taken when replacing the can to see that the wires coming in through the slots are not caught and pinched.

8.4 VOLTAGE CHECKS

As an aid in trouble shooting, the following table gives the normal voltage at significant test points.

TABLE III

Conditions:

Line input 115V, 60 cycles.

Bridge balanced at zero.

Use 20,000 ohms/volt or

VTVM for DC measurements.

Use VTVM (such as Ballantine 300) for 60 cycle and 100 KC AC measurements.

Test Point		Normal Range of Readings
Pin 7	6X4	250 - 300V DC
Pin 1,5	OA2	145 - 155V DC
Pin 4	6C4	210 - 260V DC
J4	(osc. output)	1V, RMS (100 KC) (with coax. cable off)
Pin 5	6AU6's	230 - 280V DC
Pin 6	6AU6's	130 - 150V DC
Pin 4	6X4	6.0 - 6.6V RMS (60 cy)

NOTE:
All voltage tests to ground.

8.5 CONDUCTANCE TESTS

1. To check the operation of the condutance measuring circuit, first set the DIVIDE G/MULTIPLY R switch at "1", the MULTIPLY CAPACITANCE switch at "1", and the CAPACITANCE dial at "0".

Then balance the bridge using the COARSE and FINE capacitance controls and the CONDUCTANCE dial. The conductance zero set control (located directly above the CONDUCTANCE dial) should have the pointer straight up.

Balance should be reached with the CONDUCTANCE dial at or near zero (within ± 10 micromhos).

2. With the CONDUCTANCE dial left at the setting that gave balance on the "1"range, it should be possible to achieve a conductance balance on the other DIVIDE G/ MULTIPLY R ranges in either DIRECT or GROUNDED positions of the GROUNDED-DIRECT switch using only the conductance zero control and the COARSE and FINE capacitance zero controls.

3. A quick test of operation on all DIVIDE G/MULTIPLY R ranges may be performed using 1K, 10K, 100K, 1 megohm and 10 megohm ± 1% film (deposited carbon) type resistors.

a. First set up as in step 1. Then connect the 1K ohm resistor to the HI and LO TEST posts, and balance the Bridge using the CONDUCTANCE and CAPACITANCE dials. Read the indicated value on the CONDUCTANCE dial.

b. Remove the resistor, switch to "10" on the DIVIDE G/MULTIPLY R control, and re-balance using the conductance zero control and the COARSE and FINE capacitance controls. Connect the 10K ohm resistor and again balance using the CONDUCTANCE and CAPACITANCE dials. Read the indicated resistance value on the CONDUCTANCE dial and multiply by 10.

c. Repeat the procedure of step b. on the "100" range, the "1K" range, and the "10K" range using the 100K ohm, 1 megohm and 10 megohm resistors respectively. Readings should fall with ± 11% of full scale on the CONDUCTANCE dial in each case (see "Resistance Accuracy" specifications of Section IV, RANGE and ACCURACY.)

8.6 100 KC OSCILLATOR AND AMPLIFIER CHECK AND ADJUSTMENT

1. Unless the 100 KC oscillator tuning (OSC ADJ) control has been re-set, or the 100 KC IF transformer (T4, T5, T6) adjustments disturbed, no adjustment of these tuned circuits should be required.

2. To check for satisfactory operation of the 100 KC circuits, set the GROUNDED-DIRECT switch to DIRECT, the DIVIDE G/MULTIPLY R switch on "1K" the MULTIPLY CAPACITANCE control to "0.001" and the SENSITIVITY control full on. Turn the CAPACITANCE dial to zero and balance the bridge.

   Turning the CAPACITANCE dial 1 μμf (effective change being 1 X.001 or 0.001 μμf.) in either direction from balance should produce a change in meter reading of at least 25 microamperes.

3. If a change of less than 25 microamperes is observed it is possible that the 100 KC oscillator is not properly set to the IF frequency. To check this, disconnect the coax cable from J3, and with the SENSITIVITY control at maximum carefully set OSC ADJ for highest meter reading. Re-connect to J3 and repeat step 2 to determine whether or not satisfactory sensitivity has been achieved.

4. If sensitivity is still inadequate, again remove the connector from J3 and peak the trimmers of T4, T5 and T6 for maximum meter reading. (There will be sufficient pick-up of the 100 KC oscillator to serve as the peaking signal input).

8.7 CHECK OF CAPACITANCE ACCURACY ON "1" RANGE OF MULTIPLY CAPACITANCE SWITCH

The variable capacitor has been very accurately adjusted at the factory to insure tracking with the CAPACITANCE dial calibration. The accuracy at the 1000 μμf point may be determined as follows:

1. Balance the bridge with the CAPACITANCE and CONDUCTANCE dials at 0 and the GROUNDED-DIRECT switch on DIRECT. After balancing, set the ADD CAPACITANCE switch on "1K". Connect an adjustable capacitor (preferably made up of fixed silver mica units padded with a small air variable, and contained in a shielded case) between the HI and LO TEST posts of the bridge, with the case to the GND post. Re-balance the bridge by varying the external capacitor and the CONDUCTANCE dial.

2. Turn the ADD CAPACITANCE switch to "0". Re-balance the bridge using the CAPACITANCE and CONDUCTANCE dials. The CAPACITANCE dial should read 1000 ± 1.5 μμf.

8.8 CHECK OF OTHER RANGES

If the preceding check of the 1000 μμf point has shown good agreement, it is reasonably certain that the calibration can be relied on over the entire dial. If desired, however, it may be checked by the step-up method. Similarly the accuracy of each of the other ranges may be determined by transfer downward (for example the exact dial reading for 100 μμf on the "1" range may be determined by step-up, then the external air variable adjusted for bridge balance at that reading and used to check full scale on "0.1" range).

Three-terminal capacitance standards (Model CS-), at any requested value between 0.01 μμf and 1000 μμf, are available on order for use in checking or re-calibrating the bridge.

SECTION IX

APPLICATIONS

9.1 DIFFERENTIAL MEASUREMENTS

1. Description

The bridge may be used to measure very small capacitance differences between fairly large capacitors, hence is capable of making measurements of very small temperature coefficients. The use of the direct method of measurement avoids errors resulting from stray or variable capacitance to ground.

2. Operating Procedure for Differential Measurements

a. Switch to DIRECT. Plug the accessory board into the banana jacks (beneath the port cover) on top of the cabinet.

b. Set the CAPACITANCE dial at mid-scale (500 μμf). Select a MULTIPLY CAPACITANCE switch position that will give a suitable range of capacitance. Either the ".01" or ".001" range may be required, depending on the range of expected capacitance differential.

c. Balance the bridge, using the COARSE and FINE capacitance controls and the conductance vernier.

d. Connect the reference capacitor to the front two terminals of the accessory board (on top of the cabinet), and the other to the HI and LO TEST posts on the front of the Bridge.

e. Adjust the CAPACITANCE and CONDUCTANCE dials of the bridge to restore balance. (The conductance reading is the difference in conductance between the reference capacitor and the test, hence should not be considered as reflecting the actual conductance of either capacitor).

f. The μμf difference in CAPACITANCE dial reading from 500.0 μμf, times the MULTIPLY CAPACITANCE factor used, will be the differential in μμf. The dial reading is direct sensing; that is, a higher-than-500 μμf reading indicates that the capacitor on the HI and LO TEST posts is higher in capacitance than the reference.

3. SUGGESTION FOR OBTAINING GREATEST ACCURACY

Additional accuracy can also be obtained by inter-changing the two capacitors and re-measuring their difference. Ideally the amount of difference from 500 μμf should be identical, but the readings should be in opposite directions from the 500 μμf point. Errors may be minimized by averaging the two differences from 500 μμf and using the average as the measure of differential.

4. TEMPERATURE COEFFICIENT MEASUREMENTS

Probably the most useful application of the differential method of measurement is in determining the temperature coefficient of capacitors.

Here the "Direct" method of measurement is invaluable, for it allows the use of flexible shielded cables between the bridge and the capacitor to be tested, without introducing errors due to cable or stray capacitance to ground. Standard temperature chambers thus may be used without the usual elaborate access provisions.

A stable reference capacitor should be used, preferably one of low temperature coefficient to minimize the effects of room temperature variations. An Auxiliary Capacitor (Type AC-1), designed for this use, is available on order. This, plus the built-in features of the Bridge, enables measurements of the temperature coefficient of capacitors between 0 and 11,000 μμf.

For temperature coefficient measurements the Bridge and reference capacitor should be given sufficiant warm-up time to stabilize both (preferably at least 5 hours).

No external reference capacitor is necessary when the capacitor to be tested is less than 10 μμf. In this case the CAPACITANCE dial can be set to 500 μμf (mid-scale) on either the ".01" or ".001" range, and the COARSE and FINE controls used to balance the Bridge (in place of a "reference" capacitor).

9.2 CAPACITANCE AND CONDUCTANCE MEASUREMENTS OF SEMICONDUCTORS

1. LOW DISTORTION OSCILLATOR

To reduce turnover* error when measuring semiconductor diodes, the 100 KC oscillator has been designed to have unusually low harmonic distortion.

*A change in capacitance or conductance reading when the diode and the bias polarity have been simultaneously reversed at the test connections.

2. VARIABLE TEST SIGNAL LEVEL

Built-in means are provided for varying the level of the 100 KC test signal. A switch and potentiometer (accessible from the rear of the cabinet) allow control between a high of 3V and a useful low of approximately 20 mv across the TEST posts.

An accessory fixed attenuator (Model 75-1A) may be used to reduce the level of test signal by approximately 40 db (thus producing an adjustment range from about 40 mv to below 1 mv).

3. BUILT-IN VARIABLE DC BIAS

A special model (74C-S8) incorporating an integral DC bias supply is available for use when it is necessary to apply DC bias to the semiconductor under test.

Bias voltages are adjustable to +100 V or -5V, with a maximum DC of 10 ma. The maximum bias available varies with the range setting of the DIVIDE G/MULTIPLY R switch.

R/G SWITCH RANGE	APPROXIMATE MAXIMUM DC BIAS VOLTAGE	
	+	-
10K	100	5
1K	100	5
100	90	5
10	30	4.9
1	5	4.5

SECTION X

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SECTION XI

WARRANTY

Boonton ELECTRONICS Corporation guarantees to the original purchaser that each instrument it manufacturers be free from defects in material and workmanship for a period of one year after date of initial shipment. Our liability is limited to repairing or replacing any defective part with the exception of vacuum tubes, panel lamps, fuses, choppers, and batteries. The warranty lapses if, upon our examination, we judge that the instrument has been abused in any way.

PROCEDURE TO FOLLOW WHEN INSTRUMENT IS DEFECTIVE

1. Call our plant or our representative nearest you. A simple solution may result from discussion of the problem with our trained personnel.
2. If the fault is not readily eliminated, prepare the instrument for return to us. Pack carefully in a sturdy container using several inches of shock absorbing material on all six sides of the instrument. Include all probes, cables, or accessory units. On all paper work pertaining to the returned instrument, note the model and serial number and state briefly the details of the fault. Ship to us transportation charges prepaid.
3. If the instrument is within the warranty, we will repair and return to you transportation charges prepaid. If the instrument is beyond the one year warranty period, we will repair and return it unless approval on a cost estimate is requested. If the instrument is within the one year warranty period, but our examination reveals abuse, we will await approval of our cost estimate before proceeding with repairs.

SECTION XII

TABLE OF REPLACEABLE PARTS

NOTE:

Components in the "bridge" section have not been included, since in general their replacement must be followed by adjustments that require specialized equipment and techniques.

Reference		Description	BEC Part Number
C1	Capacitor	2000 μμf ± 5% 500V	200,500
C2	"	470 μμf ± 2% 500V	200,501
C3	"	0.05 μf 400V	230,110
C4	"	0.05 μf 400V	230,110
C21	"	0.01 μf 400V	230,111
C23	"	5 μf 6V	283,108
C25	"	0.01 μf 400V	230,111
C27	"	0.05 μf 400V	230,110
C29	"	0.01 μf 400V	230,111
C31	"	5 μf 6V	283,108
C32	"	0.01 μf 400V	230,111
C33	"	100 μμf ± 5% 500V	200,001
C34	"	0.05 μf 500V	224,109
C35a	"	20 μf 450V	P/O 283,100
C35b	"	20 μf 450V	P/O 283,100
C37	"	0.05 μf 500V	224,109
D1	Diode	IN34A	530,005
F1	Fuse	AGC 0.5 Amp.	545,502
F2	Fuse	AGC 0.5 Amp.	545,502

Reference	Description	BEC Part Number
L1 Choke, 7hy	Stancor C1707	440,001
M1 Meter, 22μa	Marion MM2	554,116
PL-1 Bulb	#47	545,101
R1 Resistor	220K Ω 1/2W 10%	301,143
R2 "	2.2K Ω 1/2W 10%	301,015
R3 "	2.2K Ω 1/2W 10%	301,015
R15 "	470K Ω 1/2W 5%	301,029
R16 "	1 Meg 1 W 20%	302,128
R17 "	470 Ω 1/2W 10%	301,011
R18 "	10K Ω Var. 2W 10%	311,124
R19 "	10K Ω 1/2W 10%	301,019
R20 "	470K Ω 1/2W 10%	301,029
R21 "	470K Ω 1/2W 10%	301,029
R22 "	470 Ω 1/2W 10%	301,011
R23 "	10K Ω 1/2W 10%	301,019
R24 "	68K Ω 1/2W 10%	301,024
R25 "	7.5K Ω 10W 10%	312,100
R26 "	27K Ω 1W 5%	302,135
R27 "	470 Ω 1/2W 5%	301,079
R28 "	47K Ω 1W 5%	302,141
R29 "	50K Ω Var. (Linear) 2W 10%	311,125

Reference		Description	BEC Part No.
S1	Switch, Toggle DPST	Carling #216-62	465,100
S6	Switch, Toggle DPST	AH & H 81027AZ	465,101
T1	Oscillator Coil	Special	074,024
T7	Transformer, Power	Stancor PC 8401	446,007
TS-1	Terminal Shield		074,022
V1	Tube	6C4	526,6C4
V2	Tube	6AU6	526,6AU6
V3	Tube	6AU6	526,6AU6
V4	Tube	6X4	526,6X4
V5	Tube	OA2	526,OA2

1000 CYCLE DIRECT CAPACITANCE BRIDGE

Normal Operating Voltages

Conditions:

Line input 115V 60∿

TEST POINT	NORMAL OPERATING VOLTAGES	
	DC	AC
V5 6X4 Pin 7	360 - 390V	
V5 6X4 Pin 4		6 - 6.6V (60∿)
V6 OA2 Pin 1,5	150V	

1000 Cycle Oscillator and Indicator Amplifier Adjustments

The 1000 cycle RC Oscillator is provided with two adjustment controls, accessible at the top of the chassis. One, marked OSC FREQ, may be used to control the operating frequency of the oscillator over a narrow range. The other, marked OSC FDBK (LEVEL), controls the feedback in the oscillator. It should be set to give approximately 36 VRMS at the OSC OUTPUT BNC receptacle (with the cable to the bridge input transformer disconnected from the receptacle).

The procedure for tuning is to first adjust the oscillator frequency to approximately 990 CPS (chosen to minimize the effects of beating with line harmonics). This adjustment should be made with the bridge input transformer connected.

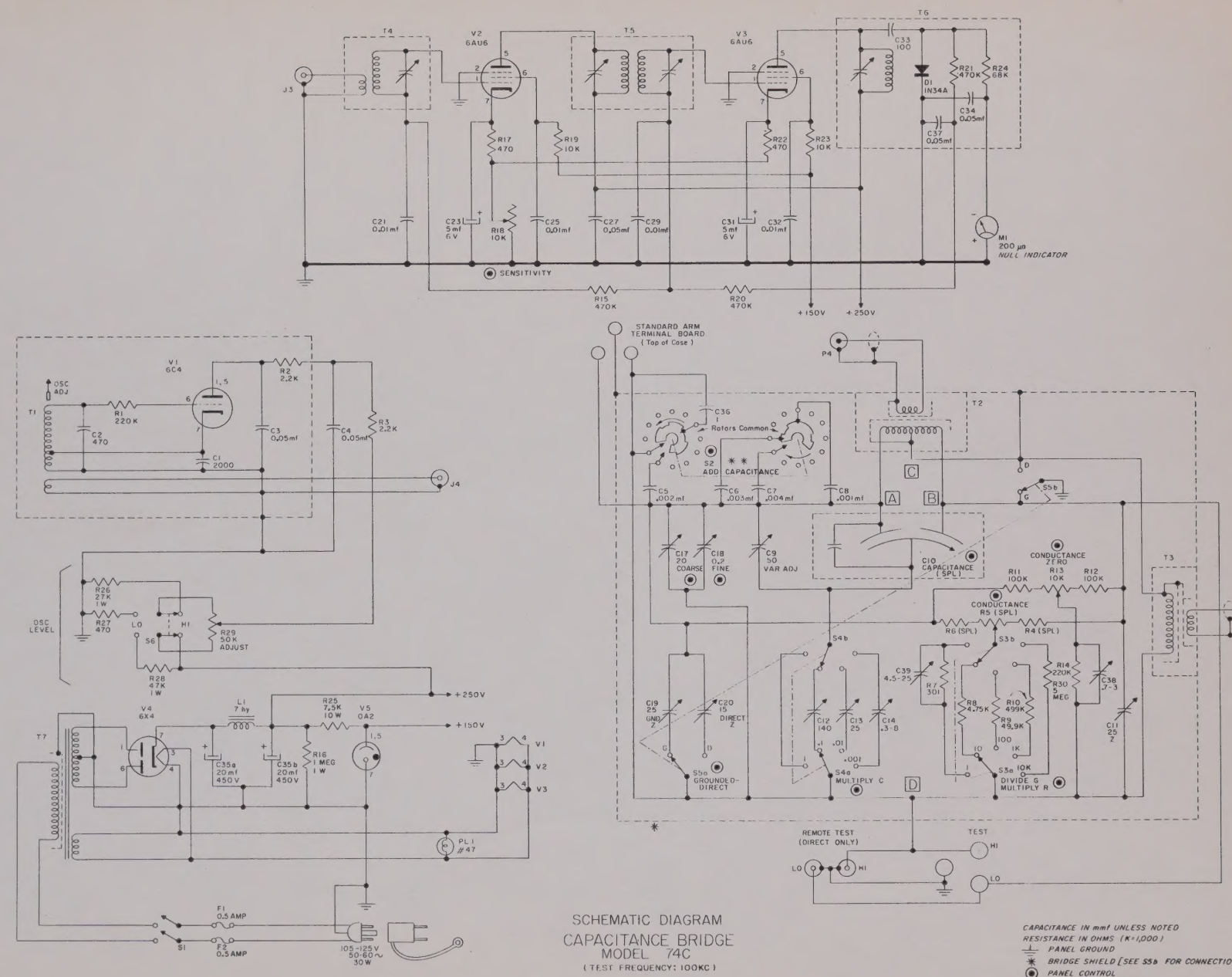
The next step is to tune the amplifier to the oscillator frequency. Balance the bridge, then mis-tune slightly for a meter reading of about 20 or 25 μa. Using C38, located underneath the chassis in the plate tank of V2. Tune for a maximum reading on the NULL INDICATOR meter.

Check of Indicator Sensitivity

To check indicator sensitivity, set the DIVIDE G/MULTIPLY R switch on 10K, the MULTIPLY CAPACITANCE control on .001, and turn the SENSITIVITY control full on. Set the CAPACITANCE dial at 0. Balance the bridge. Normal indicator sensitivity is that which produces a NULL INDICATOR meter reading of approximately 60 μa for a CAPACITANCE dial setting of 10 dial μμf away from zero.

Test Signal Level

The normal level of the TEST signal is approximately 1.5 VRMS. It may be measured between the LO TEST binding post and panel ground.



SCHEMATIC DIAGRAM
CAPACITANCE BRIDGE
MODEL 74C
(TEST FREQUENCY: 100KC)

Boonton *ELECTRONICS* Corp
MORRIS PLAINS, N.J.

CAPACITANCE IN mmf UNLESS NOTED
RESISTANCE IN OHMS (K=1,000)
⏚ PANEL GROUND
✱ BRIDGE SHIELD [SEE S5b FOR CONNECTIONS]
◉ PANEL CONTROL
✱✱ 0 TO 10,000 mmf IN 1,000 mmf STEPS

830,002G

MP MASTER
MA24755